Charge asymmetry in $\pi^+\pi^-$ electroproduction on proton at high energies as a test of σ, ρ mesons degeneration

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Abstract
The charge asymmetry induced by interference of amplitudes with σ and ρ mesons decaying to $\pi^+\pi^-$ pair created in the fragmentation region of proton, suggest to be a test of degeneration hypothesis of ρ and σ mesons. Some numerical estimations are given.

1 Introduction

Theoretical reasons for existence of scalar neutral meson (σ-meson) was formulated in late 60-th [1]. It was recognized that the chiral as well as scaling symmetry of strong interactions are violated, which can be realized within effective lagrangian by including scalar field $\sigma(x)$. In the frame QCD it was shown that breaking of scale invariance is related to the trace of energy-momentum tensor [2]. In the papers of Schehter, Ellis and Lanik [3] the effective QCD lagrangian with broken scale and chiral symmetries was constructed,where scalar gluonic current was related with $\sigma(x)$: $G^2_{\mu\nu} \sim m^4_\sigma \sigma(x)^4/G_0, G_0 =< 0|(\alpha_s/\pi G^2_{\mu\nu}|0 >= 0.017 GeV^4$- is gluonic condensate. Besides the widths of 2 pion and 2 gamma decay channels it was obtained:

$$\Gamma(\sigma \to \pi^+\pi^-) = \frac{m^5_\sigma}{48\pi G_0}, \quad \Gamma(\sigma \to \gamma\gamma) = \frac{3}{4}\left(\frac{R\,\alpha}{8\pi^2}\right)^2 \Gamma(\sigma \to \pi^+\pi^-), \tag{1}$$

with $R = \sigma(e^+e^- \to hadrons)/\sigma(e^+e^- \to \mu^+\mu^-)$. Experimental evidence of possible existence of $\sigma(750)$ was obtained in CERN experiments for process $\pi^- p \to \pi^-\pi^+ n$ [4, 5] with polarized target. In S. Weinberg paper [6] it was shown the relation $m_\rho = m_\sigma$ as a consequence of broken chiral symmetry. A similar statement follows from the analysis of superconvergent sum rules for helicity amplitudes, as was shown in the paper of Gillman and Harari [7]. Really, taking this value for σ meson we obtain for its total (mainly 2 pion) width $\Gamma(\sigma \to 2\pi) = 150 MeV = \Gamma_\rho$.

To obtain the independent evidence of σ and besides the validity of the degeneracy $m_\rho = m_\sigma$, $\Gamma_\rho = \Gamma_\sigma$ we suggest to measure the charge asymmetry of two pion production at electron-proton collisions:

$$e(p_1) + p(p) \to e'(p_1') + p'(p') + \pi^+(q_+) + \pi^-(q_-), \tag{2}$$

which is defined as follows:

$$\begin{aligned} A_c &= \frac{d\sigma(q_1,q_2) - d\sigma(q_2,q_1)}{d\sigma(q_1,q_2) + d\sigma(q_2,q_1)} \\ &= \frac{N(\pi^+(q_1),\pi^-(q_2)) - N(\pi^+(q_2),\pi^-(q_1))}{N(\pi^+(q_1),\pi^-(q_2)) + N(\pi^+(q_2),\pi^-(q_1))}, \end{aligned} \tag{3}$$

where $d\sigma(q_1,q_2)$ means the inclusive cross section with π^- meson with momentum q_1 and π^+ with momentum q_2, $N(\pi^+(q_1),\pi^-(q_2))$-number of corresponding events.

2 Calculation of asymmetry

Charge asymmetry can be more pronounced at invariant mass of pions close to the ρ meson mass,where due to Breit-Wigner enhancement of cross section the counting rate is expected to be large.

Matrix element in this region can be put in form $\mathcal{M} = \mathcal{M}_\rho + \mathcal{M}_\sigma$ (see fig.1). Then the charge asymmetry will have a form

$$A_c = \frac{2\mathcal{M}_\rho(\mathcal{M}_\sigma)^*}{|\mathcal{M}_\sigma|^2 + |\mathcal{M}_\rho|^2}. \tag{4}$$

To obtain the realistic estimation magnitude of the effect we take into account only Feynman amplitudes containing the σ, ρ intermediate states.

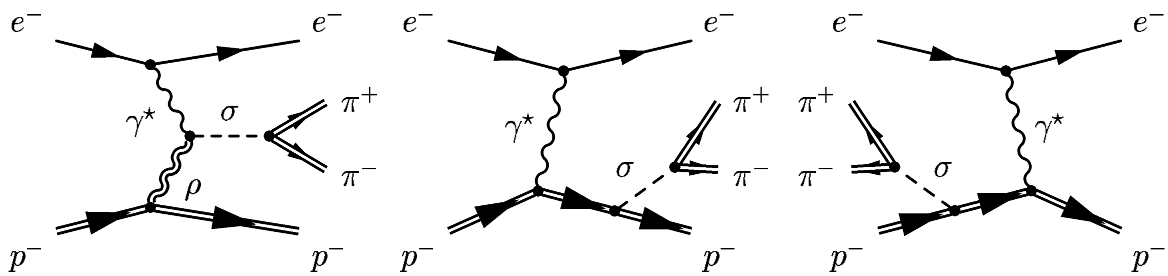

Figure 1: Feynman Diagrams (FD) for matrix element $\mathcal{M}_\sigma$. By exchange $\sigma \to \rho, \rho \to \sigma$ one can obtain FD for $\mathcal{M}_\rho$

In Appendix we give the cross section and the asymmetry in kinematics of fragmentation of proton both in exclusive and inclusive set-up.

Matrix elements have the form:

$$\begin{aligned} \mathcal{M}_\sigma &= J_\mu \bar{u}(p') T^\mu u(p) R_\sigma g_{\sigma\pi\pi} g_{\sigma nn}, \\ \mathcal{M}_\rho &= J_\mu \bar{u}(p') T^{\mu\nu} u(p) (q_- - q_+)^\nu R_\rho g_{\rho\pi\pi} g_{\rho nn}, \end{aligned} \tag{5}$$

with (for kinematics see (2))

$$\begin{aligned} J_\mu &= \frac{4\pi\alpha}{Q^2} \bar{u}(p_1') \gamma_\mu u(p_1), \quad R_{\sigma,\rho} = \frac{1}{s_1 - m^2_{\sigma,\rho} + i(m\Gamma)_{\sigma,\rho}}, \\ Q^2 &= -q^2, \quad s_1 = q_2^2, \quad q_2 = q_+ + q_-, \quad q = p_1 - p_1'. \end{aligned} \tag{6}$$

Besides $g_{\rho\pi\pi} = 4\sqrt{3\pi/\beta_\rho^3}\sqrt{\Gamma_\rho/m_\rho}$ and $g_{\sigma\pi\pi} = 4\sqrt{\pi/\beta_\sigma}\sqrt{m_\sigma \Gamma_\sigma}$ - are the coupling constant, $\beta_{\rho,\sigma} = \sqrt{1 - (4m_\pi^2/m^2_{\rho,\sigma})}$ - the velocity of pions in the rest frame of decaying σ or ρ mesons.

The hadronic currents obey the current conservation condition:

$$\bar{u}(p') T_\mu u(p) q^\mu = 0, \quad \bar{u}(p') T^{\mu\nu} u(p) q_\mu = 0, \quad \bar{u}(p') T^{\mu\nu} u(p) q_{2\nu} = 0. \tag{7}$$

The expressions for T we had used are:

$$T^\mu = \Lambda \frac{1}{q_1^2 - m_\rho^2} R_1^{\mu\nu} \gamma_\nu + \frac{\hat{p} + \hat{q} + m_p}{(p+q)^2 - m_p^2} \gamma^\mu + \gamma_\mu \frac{\hat{p}' - \hat{q} + m_p}{(p'-q)^2 - m_p^2}, \tag{8}$$

and

$$T^{\mu\nu} = \frac{1}{\Lambda} \frac{1}{q_1^2 - m_\sigma^2} R_2^{\mu\nu} + \gamma_\nu \frac{\hat{p} + \hat{q} + m_p}{(p+q)^2 - m_p^2} \gamma_\mu + \gamma_\mu \frac{\hat{p}' - \hat{q} + m_p}{(p'-q)^2 - m_p^2} \gamma_\nu, \tag{9}$$

with $\Lambda = g_{\rho nn}/g_{\sigma nn}$, $q_1 = p - p'$. The vertex $\gamma^*\sigma\rho$ we parameterize as

$$R_{1,2}^{\mu\nu} = \frac{g\, m}{m^2 + Q^2}(q^\nu q_{1,2}^\mu - g^{\mu\nu} q q_{1,2}), \tag{10}$$

which is an anzatz, inspired by low-order triangle Feynman diagram calculation, $m = 300 MeV$ is the constituent quark mass. The coupling g is chosen in such a way to reproduce the $(g_{\rho\pi\pi}/e)^2\Gamma(\sigma \to \gamma\gamma)$. The factor $(g_{\rho\pi\pi}/e)^2$ is introduced to take into account the replacement of one of photons by vector meson. Our estimate gives $g \approx 2$.

By calculating matrix element which are given above we obtain charge asymmetry in the form:

$$A_c = \frac{2[(s_1 - m_\rho^2)(s_1 - m_\sigma^2) + m_\rho m_\sigma \Gamma_\rho \Gamma_\sigma] Q^{\mu\lambda}(q_- - q_+)^\nu Z_{\mu\nu\lambda} \Lambda g_{\rho\pi\pi} g_{\sigma\pi\pi}}{Q^{\eta\sigma}[|R_\rho|^{-2} Z_{\eta\sigma} g_{\sigma\pi\pi}^2 + \Lambda^2 |R_\sigma|^{-2} Z_{\eta\mu_1\sigma\nu_1} g_{\rho\pi\pi}^2 (q_- - q_+)_{\mu_1}(q_- - q_+)_{\nu_1}]} \tag{11}$$

with

$$\begin{aligned} Q^{\mu\nu} &= 2p_1^\mu p_1^\nu + (Q^2/2) g^{\mu\nu}, \\ Z_{\mu\nu\lambda} &= Tr(\hat{p}' + m_p) T_\mu (\hat{p} + m_p) \tilde{T}_{\lambda\nu}, \\ Z_{\eta\sigma} &= Tr(\hat{p}' + m_p) T_\eta (\hat{p} + m_p) \tilde{T}_\sigma, \\ Z_{\eta\mu_1\sigma\nu_1} &= Tr(\hat{p}' + m_p) T_{\eta\mu_1} (\hat{p} + m_p) \tilde{T}_{\sigma\nu_1}. \end{aligned} \tag{12}$$

For inclusive set-up (pions as well as the scattered electron are detected) the numerator and the denominator must be integrated by phase volume of the scattered proton.

3 Discussion

We neglect above final-state pion and pion-nucleon interaction which cause the pion-pion scattering phases [8]. It can be justified within 5% accuracy for the case of rather large effective mass of pions in the final state.

In the Tables 1-4 we present x_+, x_- distribution (which means energy fraction of π^+ and π^- in the case of the energies of experiment H1) for the equal mass case $m_\sigma = m_\rho = 769$ MeV and different mass case.

The integration of asymmetry was made over variables $\vec{q}_\pm$ in the region $0.01 - 0.9$ GeV for each x, y component of the vector $\vec{q}_\pm$:

$$Ac_{int}(x_+, x_-, Q) = \frac{\int d^2q_+ \int d^2q_- 2\mathcal{M}_\rho (\mathcal{M}_\sigma)^*}{\int d^2q_+ \int d^2q_- (|\mathcal{M}_\sigma|^2 + |\mathcal{M}_\rho|^2)} \tag{13}$$

We see that the case $m_\sigma = m_\rho$ can be unambiguously separated from the $m_\sigma \neq m_\rho$ case within 5% accuracy of experimental data.

Asymmetry have a magnitude of order 1 ($|A_c| \sim 1$) in the fragmentation region of initial proton for small values of momentum transferred $Q \sim 0.5$ GeV $\ll \sqrt{s} \sim 100$ GeV (DESY, H1). At higher Q it degrees rapidly: for $Q \sim 3$ GeV $|A_c| < 0.1$.

In tables 5-7 we give asymmetry as function of angles θ_+, θ_- for HERMES case of energies, $\theta_\pm = \widehat{p_e q_\pm}$, integrated over $\varepsilon_+, \varepsilon_-$ (energies of π_+, π_-) in the region $0.5 - 20$ GeV, and over angles ϕ_+, ϕ_- ($\phi_\pm = \widehat{q_\perp q_{\pm\perp}}$) in the region $0 - 2\pi$, $Q = 0.2$ GeV:

$$Ac_{int}(\theta_+, \theta_-, Q = 0.2) = \frac{\int\limits_0^{2\pi}\int\limits_0^{2\pi} d\phi_+ d\phi_- \int\int d\varepsilon_+ d\varepsilon_- 2\mathcal{M}_\rho (\mathcal{M}_\sigma)^*}{\int\limits_0^{2\pi}\int\limits_0^{2\pi} d\phi_+ d\phi_- \int\int d\varepsilon_+ d\varepsilon_- (|\mathcal{M}_\sigma|^2 + |\mathcal{M}_\rho|^2)} \qquad (14)$$

Note that asymmetry in tables 5-7 turns to zero not only when $\theta_+ = \theta_-$, but also at points $\theta_+ = -\theta_-$.

In all numerical estimates given in tables we used the next values:

$$\Lambda = \frac{g_{\rho nn}}{g_{\sigma nn}} = 1, \quad m = 0.300\ GeV, \quad m_\rho = 0.769\ GeV, \qquad (15)$$
$$\Gamma_\rho = \Gamma_\sigma = 150\ GeV, \quad M_p = 0.98\ GeV, \quad m_\pi = 0.139\ GeV.$$

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5 Appendix

In proton fragmentation region (invariant mass of the scattered proton jet) $(p' + q_+ + q_-)^2 \ll s = 2pp_1$ we can use Sudakov decomposition of 4-momenta

(2):

$$q=\beta\tilde{p}_1+\alpha\tilde{p}+q_\perp,\quad q_\pm=\beta_\pm\tilde{p}_1+x_\pm\tilde{p}+q_{\pm\perp},\quad p'=\beta'\tilde{p}_1+x\tilde{p}+p_\perp,\quad (16)$$
$$\tilde{p}_1=p_1-p\frac{m_1^2}{s},\quad \tilde{p}=p-p_1\frac{m_p^2}{s},$$

with conservation law and on mass shell conditions:

$$\frac{m_p^2}{s}+\beta=\beta_++\beta_-+\beta',\quad \vec{q}=\vec{q}_++\vec{q}_-+\vec{p},\quad x+x_-+x_+=1,\quad (17)$$
$$s\beta_\pm=A_\pm=\frac{1}{x_\pm}[m_\pi^2+\vec{q}_\pm^{\,2}],\quad s\beta'=A=\frac{1}{x}[m_p^2+\vec{p}^{\,2}].$$

Above we put designations for transversal components of 4-vectors:

$$\vec{q}_\pm^{\,2}=-q_{\pm\perp}^2,\quad \vec{p}^{\,2}=-p_\perp^2,\quad (18)$$

and m_p (m_π) are mass of proton (pion).

Phase space volume

$$d\Gamma=(2\pi)^{-8}\frac{d^3p_1'}{2\epsilon_1'}\frac{d^3p'}{2\epsilon'}\frac{d^3q_+}{2\epsilon_+}\frac{d^3q_-}{2\epsilon_-}\delta^4(p_1+p-p'-p_1'-q_+-q_-)$$

can be transformed to the form:

$$d\Gamma=(2\pi)^{-8}\frac{d^2\vec{q}d^2\vec{q}_+d^2\vec{q}_-}{8s}\frac{dx_+dx_-}{x_+x_-(1-x_+-x_-)}.\quad (19)$$

Matrix element,using the Gribov's representation for metric tensor

$$g^{\mu\nu}=g_\perp^{\mu\nu}+\frac{2}{s}[\tilde{p}_1^\mu\tilde{p}^\nu+\tilde{p}_1^\nu\tilde{p}^\mu]$$

can be written in form:

$$\mathcal{M}=\frac{8\pi\alpha is}{q^2}N(\Phi_\rho g_{\rho\pi\pi}g_{\rho nn}+\Phi_\sigma g_{\sigma\pi\pi}g_{\sigma nn}),\quad (20)$$
$$N=\frac{1}{s}\bar{u}(p_1')\tilde{p}u(p_1),\quad \Sigma|N|^2=2;$$

and

$$\Phi_{\sigma,\rho}=\frac{R_{\sigma,\rho}}{s}\bar{u}(p')O_{\sigma,\rho}u(p),\quad (21)$$

with

$$O_\sigma = as\hat{q} + b\hat{p}_1 + \frac{1}{d}(\hat{p} + \hat{q} + M)\hat{p}_1 + \frac{1}{d'}\hat{p}_1(\hat{p}' - \hat{q} + M), \qquad (22)$$

$$O_\rho = cs + \frac{1}{d}(\hat{q}_- - \hat{q}_+)(\hat{p} + \hat{q} + M)\hat{p}_1 + \frac{1}{d'}\hat{p}_1(\hat{p}' - \hat{q} + M)(\hat{q}_- - \hat{q}_+). \qquad (23)$$

Asymmetry (11) in the exclusive set-up (the scattered electron as well as all component of pions momenta are registered) have a form

$$A_c = \frac{2\Sigma Re(\Phi_\rho \Phi_\sigma^*)}{\Sigma|\Phi_\rho|^2 \Lambda^2 g_{\rho\pi\pi}^2 + \Sigma|\Phi_\sigma|^2 g_{\sigma\pi\pi}^2} \Lambda g_{\rho\pi\pi} g_{\sigma\pi\pi}, \qquad (24)$$

where the sum over the fermion's spin states is implied. The asymmetry as well as the cross section do not depend on s in the large s limit. The notations are:

$$a = \frac{\Lambda\, g\, m\, (1-x)}{2(m^2+Q^2)(q_1^2 - m_\rho^2)}, \quad b = -\frac{\Lambda\, g\, m\, qq_1}{2(m^2+Q^2)(q_1^2 - m_\rho^2)}, \qquad (25)$$

$$c = \frac{g\, m}{2\Lambda(m^2+Q^2)(q_1^2 - m_\sigma^2)}[(qq_- - qq_+)(1-x) - (x_- - x_+)(qq_+ + qq_-)],$$

$$d = (p+q)^2 - m_p^2 = -Q^2 + A_- + A_+ + A - m_p^2,$$

$$d' = (p'-q)^2 - m_p^2 = -Q^2 + 2\vec{p}\vec{q} - x(A_- + A_+ + A - m_p^2),$$

Here we put the relevant scalar products, which appear in (25) by using Gribov representation (16-18):

$$p_1'^2 = p_1^2 = 0, \quad 2p_1 q = -2p_1' q = -Q^2, \quad p^2 = (p')^2 = m_p^2\,,$$

$$q^2 = -Q^2 = (p_1 - p_1')^2, \quad p_1 q_\pm = \frac{1}{2} s x_\pm, \quad p_1 p = \frac{s}{2}, \quad p_1 p' = \frac{sx}{2},$$

$$q_1^2 = (p - p')^2 = -\frac{1}{x}[m_p^2(1-x)^2 + \vec{p}^2],$$

$$s_1 = q_2^2 = (q_+ + q_-)^2 = -\frac{1}{x_- x_+}[m_\pi^2(x_- + x_+)^2 + (x_+\vec{q}_- - x_-\vec{q}_+)^2],$$

$$qq_1 = \frac{1}{2}[s_1 + Q^2 - q_1^2], \quad qq_\pm = -\vec{q}\vec{q}_\pm + \frac{x_\pm}{2}(A_- + A_+ + A - m_p^2),$$

$$pq_\pm = \frac{1}{2}[m_\pi^2 + \vec{q}_\pm^2 + m_p^2 x_\pm^2]\frac{1}{x_\pm}, \quad p'q_\pm = \frac{1}{2x_\pm x}[m_p^2 x_\pm^2 + x^2 m_\pi^2 + (x_\pm \vec{p} - x\vec{q}_\pm)^2],$$

$$qp = \frac{1}{2}(A_- + A_+ + A - m_p^2), \quad qp' = -\vec{q}\vec{p} + \frac{x}{2}(A_- + A_+ + A - m_p^2),$$

$$pp' = \frac{1}{2x}[m_p^2(1+x^2) + \vec{p}^2], \quad q_+ q_- = \frac{1}{2x_+ x_-}[m_\pi^2(x_+^2 + x_-^2) + (x_+\vec{q}_- - x_-\vec{q}_+)^2].$$

$x_-\backslash x_+$	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
0.1	0	-0.32	-0.51	-0.46	-0.37	-0.26	-0.15	-0.07
0.2	0.32	0	0.032	-0.037	-0.071	-0.067	-0.058	
0.3	0.51	-0.03	0	0.001	-0.039	-0.055		
0.4	0.46	0.037	-0.001	0	-0.019			
0.5	0.367	0.071	0.0398	0.0197				
0.6	0.257	0.067	0.055					
0.7	0.148	0.058						
0.8	0.07							

Table 1: Integrated Asymmetry for equal masses of σ and ρ mesons, $Q = 1.2$ GeV (for other numerical parameters see Section 3).

$x_-\backslash x_+$	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
0.1	0	-0.09	-0.39	-0.65	-0.81	-0.87	-0.84	-0.71
0.2	0.09	0	-0.06	-0.09	-0.32	-0.55	-0.59	
0.3	0.39	0.06	0	-0.039	-0.031	-0.065		
0.4	0.653	0.093	0.039	0	-0.021			
0.5	0.806	0.323	0.031	0.021				
0.6	0.869	0.547	0.065					
0.7	0.845	0.595						
0.8	0.71							

Table 2: Integrated Asymmetry for mass of σ equals 1.2 Gev, $Q = 0.7$ GeV.

$x_-\backslash x_+$	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
0.1	0	-0.83	-0.88	-0.85	-0.79	-0.71	-0.62	-0.48
0.2	0.83	0	-0.45	-0.56	-0.54	-0.47	-0.38	
0.3	0.88	0.44	0	-0.22	-0.29	-0.28		
0.4	0.85	0.55	0.22	0	-0.11			
0.5	0.79	0.54	0.29	0.11				
0.6	0.72	0.47	0.28					
0.7	0.62	0.38						
0.8	0.48							

Table 3: Integrated Asymmetry for equal masses of σ and ρ mesons, $Q = 0.7$ GeV.

$x_- \backslash x_+$	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
0.1	0	-0.788	-0.938	-0.947	-0.911	-0.841	-0.735	-0.576
0.2	0.788	0	-0.545	-0.777	-0.743	-0.642	-0.510	
0.3	0.938	0.545	0	-0.299	-0.454	-0.442		
0.4	0.947	0.777	0.299	0	-0.168			
0.5	0.911	0.743	0.454	0.168				
0.6	0.84	0.64	0.44					
0.7	0.73	0.51						
0.8	0.57							

Table 4: Integrated Asymmetry for mass of σ equals 0.469 Gev, $Q = 0.7$ GeV.

$\theta_+ \backslash \theta_-$	0.22	0.18	0.13	0.09	0.04	0	-0.04	-0.09	-0.13	-0.18	-0.22
0.22	0	0.02	0.06	0.16	0.12	-0.53	0.12	0.16	0.06	0.02	0
0.18	-0.02	0	0.07	0.23	0.29	-0.34	0.29	0.23	0.07	0	-0.02
0.13	-0.06	-0.07	0	0.22	0.45	-0.21	0.45	0.22	0	-0.07	-0.06
0.09	-0.16	-0.23	-0.22	0	0.57	-0.12	0.57	0	-0.22	-0.23	-0.16
0.04	-0.12	-0.29	-0.45	-0.57	0	0	0	-0.57	-0.45	-0.29	-0.12
0	0.53	0.34	0.21	0.12	0	0	0	0.12	0.21	0.34	0.53
-0.04	-0.12	-0.28	-0.45	-0.57	0	0	0	-0.57	-0.45	-0.29	-0.12
-0.09	-0.16	-0.23	-0.22	0	0.57	-0.12	0.57	0	-0.22	-0.23	-0.16
-0.13	-0.06	-0.07	0	0.22	0.45	-0.21	0.45	0.22	0	-0.07	-0.06
-0.18	-0.02	0	0.07	0.23	0.29	0.34	0.29	0.23	0.07	0	-0.02
-0.22	0	0.02	0.06	0.16	0.12	-0.53	0.12	0.16	0.06	0.02	0

Table 5: Integrated Asymmetry for mass of σ equals 0.469 GeV.

$\theta_+ \backslash \theta_-$	0.22	0.18	0.13	0.09	0.04	0	-0.04	-0.09	-0.13	-0.18	-0.22
0.22	0	0.03	0.10	0.22	0.09	-0.44	0.09	0.22	0.10	0.03	0
0.18	-0.03	0	0.13	0.37	0.23	-0.27	0.23	0.37	0.13	0	-0.03
0.13	-0.10	-0.13	0	0.43	0.34	-0.16	0.34	0.43	0	-0.13	-0.10
0.09	-0.22	-0.37	-0.43	0	0.36	-0.08	0.36	0	-0.43	-0.37	-0.22
0.04	-0.09	-0.23	-0.34	-0.36	0	-0.03	0	-0.36	-0.34	-0.23	-0.09
0	0.43	0.27	0.16	0.08	0.03	0	0.03	0.08	0.16	0.27	0.44
-0.04	-0.09	-0.23	-0.34	-0.36	0	-0.03	0	-0.36	-0.34	-0.23	-0.09
-0.09	-0.22	-0.37	-0.43	0	0.36	-0.08	0.36	0	-0.43	-0.37	-0.22
-0.13	-0.10	-0.13	0	0.43	0.34	-0.16	0.34	0.43	0	-0.13	-0.10
-0.18	-0.02	0	0.13	0.37	0.23	-0.27	0.23	0.37	0.13	0	-0.03
-0.22	0	0.03	0.10	0.22	0.09	-0.44	0.09	0.22	0.10	0.03	0

Table 6: Integrated Asymmetry for mass of σ equals 0.769 GeV.

$\theta_+ \backslash \theta_-$	0.22	0.18	0.13	0.09	0.04	0	-0.04	-0.09	-0.13	-0.18	-0.22
0.22	0	0.04	0.15	0.27	0.05	-0.33	0.05	0.27	0.15	0.04	0
0.18	-0.04	0	0.22	0.44	0.14	-0.19	0.14	0.44	0.22	0	-0.04
0.13	-0.15	-0.22	0	0.47	0.17	-0.10	0.17	0.47	0	-0.22	-0.15
0.09	-0.27	-0.44	0.47	0	0.13	-0.03	0.13	0	-0.47	-0.44	-0.27
0.04	-0.05	-0.14	-0.17	-0.13	0	-0.08	0	-0.13	-0.17	-0.14	-0.05
0	0.33	0.19	0.10	0.03	0.08	0	0.08	0.03	0.10	0.19	0.33
-0.04	-0.05	-0.14	-0.17	-0.12	0	-0.08	0	-0.12	-0.17	-0.14	-0.05
-0.08	-0.27	-0.44	-0.47	0	0.12	-0.03	0.12	0	-0.47	-0.44	-0.27
-0.13	-0.15	-0.22	0	0.47	0.17	-0.10	0.17	0.47	0	-0.22	-0.15
-0.18	-0.41	0	0.22	0.44	0.14	-0.19	0.14	0.44	0.22	0	-0.04
-0.22	0	0.04	0.15	0.27	0.05	-0.33	0.05	0.27	0.15	0.04	0

Table 7: Integrated Asymmetry for mass of σ equals 1.200 GeV.

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